

be a parent [generation] for channels in a successive child generation" and to correct minor grammatical errors.

Claim 4 has been amended to be independent, by incorporation of the features of original claims 1-3, from which claim 4 had previously depended. New claim 15 depends from claim 4 and is similar in scope to claim 8, as amended.

Independent claims 1, 4, 5 and 6 have each been amended to identify that the claimed methods each relate to "a multi-phase process that is chemical, physical, or both," which is carried out in a vessel. Amended claims 1 and 4 further recite "Method for operating a multiphase process that is chemical, physical, or both, in a vessel containing at least two phases, each phase being a liquid, a gas, or solid particles, ...". Basis for these amendments is found in the specification at least at page 1, lines 18-32; page 3, lines 16-34; and page 9, lines 25-30.

Claim 6 has been amended to indicate that the large scale vessel has a larger number of generations than the small scale vessel. This is to be expected in a scale-up, particularly by one of ordinary skill in the art of the invention who reads the specification. Support for this amendment may be found at least at the passage bridging pages 14 and 15 of the specification, particularly page 15, lines 8-10.

Claim 7 has been amended to specify that the hierarchical network is "inside" the claimed vessel (see, e.g., page 14, lines 3-10 and lines 23-26). As well, the features of claim 9 (now cancelled) and part of claim 8 have been incorporated into claim 7, regarding the value of D, a parameter defining the relationship between N, the number of child channels splitting off a parent channel, and the ratio of the lengths of the parent channel and the child channel.

Claim 10 has been amended to incorporate the value of D recited in claim 11 (now cancelled).

New dependent claims 15-18 specify that the claimed network is a self-similar network, which feature was recited in the original independent claims but has been split off on its own, for clarity's sake.

Traverse of Election Requirement

At page 2, paragraph 1 of the Office Action (Paper No. 5), the Examiner suggests that the claims all recite a hierarchical network of channels and flow, and thus are not distinct from each other, and would stand or fall together. Applicant traverses and respectfully submits that the claims do not all stand or fall together. The claimed hierarchical network and vessel are distinct from the claimed methods, in that the former can be used in different applications, not just in the claimed methods.

The Examiner suggests that if the claims encompass distinct inventions, then election of one group of claims is necessary: either the group I claims, for various processes (claims 1-6, but should also include new claims 14-18), or of the group II claims for various apparatus (listed as claims 7-10 in the Office Action, but which should include claims 7-8, 10, and 12-13). Applicant elects the group I claims for prosecution, with traverse. It is submitted that a search and examination of both groups I and II can be (and has been) done without undue burden to the Examiner. Therefore, continued examination of all the claims is deemed to be appropriate and is requested.

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Traverse of Rejections Over the Prior Art

Cox et al.

Claims 1-13 stand rejected as allegedly being either anticipated by, or obvious over, Cox et al., U.S. Patent 4,999,102 (Page 3, Paragraph 6 of Paper No. 5). Cox et al. is alleged to teach the same process, apparatus, and network as claimed by Applicant. Applicant traverses in view of the amended claims and for the following reasons.

Cox et al. does not teach or suggest a method of operating a "multi-phase" process, as required in claims 1, 4 and 6 and their dependent claims. Moreover, Cox et al.'s distributor cannot be used to discharge fluid from its channel exits "*substantially uniformly throughout the vessel volume*" (emphasis added), as is required in Applicant's independent claims 1, 4, 6, and 7. Cox et al., which is discussed in the present application at page 4, lines 7-9, discloses distributing and/or collecting devices that clearly differ from the injectors of the present invention. This difference between Cox et al. and the present invention is further explained at page 4, lines 14-22. The structures of Cox et al. are placed outside a vessel, at either its entry or its exit, while the networks of the present invention extend inside and throughout the vessel. Thus, as explained in the paragraph bridging pages 13 and 14 of the specification, in prior art distributors such as Cox's, every available surface area in the distributor is filled, and therefore the distributor lacks sufficient free volume for the desired reactions or processes to occur. Applicant's invention is designed to provide adequate reaction or mixing space. The gist of the present invention lies in the way in which the

fluid is injected, through Applicant's branching network, into and throughout a vessel. This special way of injecting can only be obtained by the features of the present claims and leads to the unexpected results discussed in the application, including substantially uniform distribution of fluid / reactants throughout the vessel volume, as well as easy and predictable scalability from a small, test system to a larger system, and facilitated construction of the large vessel without changing flow pattern (see, e.g., pages 14-15, including page 15, lines 6-10). Cox also does not teach or suggest the same geometry and dimensional relationship of Applicant's network (see, e.g., claims 3, 4, 7, 8, 10). Cox also fails to teach the specific processes in which Applicant's invention may be used (claim 5). Finally, nothing in Cox et al. teaches or suggests Applicant's method of predictably scaling up a "multi-phase process that is chemical, physical, or both, and that is carried out in a vessel" (e.g., claim 6 and their dependent claims).

In fact, Applicant further submits that neither Cox et al. or any of the applied references (discussed later in greater detail) suggests that the structures described therein can be used for scale-up purposes. As outlined at page 3 of the specification and attested to in the enclosed Declaration by Dr. Marc-Olivier Coppens, paragraph 5, a person ordinarily skilled in the art of the invention is and was well aware that rules to scale up multi-phase processes have been unpredictable until now, with scale-up from a laboratory to an industrial setting typically being empirical or at least semi-empirical. That is, scale-up attempts have been largely trial-and-error, involving cumbersome experiments with intermediate-sized scale-ups, prior to design and construction

of a final, industrial-sized plant, which may not perform according to the desired standards. Even so, significant and costly errors have arisen in past scale-ups of multi-phase processes, because such processes are influenced by the hydrodynamics of the particular process and vessel geometry. It has been a serious challenge to maintain similar hydrodynamics during scale up from small-scale to large-scale with known methods. In most cases, this even has been impossible. That is, until Applicant's invention, there was an unfulfilled need for a reliable model to predict the behavior of multi-phase processes, even upon scale-up. The present invention provides a substantial improvement over the prior art, by enabling predictable scale-up, while maintaining the same hydrodynamics, simply by keeping the parameters N , D , and Δ , the same for small- and large-scale processes. (See, Coppins Declaration, paragraph 5, for further details.)

Therefore, for the foregoing reasons, Applicant respectfully submits that the invention as claimed is novel and non-obvious over Cox et al., and requests the withdrawal of the rejections based on that reference.

Kearney et al., U.S. Patent No. 5,354,460

Claims 1-13 stand rejected as allegedly anticipated by, or obvious over, Kearney et al., U.S. Patent No. 5,354,460, which allegedly sets forth the same process, apparatus, and network as in Applicant's claims. Kearney is alleged to provide a fluid distribution network that progressively splits the fluid flow into smaller uniform fractions prior to distributing the fractions into another media. Kearney's Figures 3-4 allegedly show the same structure as in Applicant's Figs. 1-3. Applicant traverses in view of the amended claims and the following remarks.

Like Cox et al., Kearney fails to teach or to suggest Applicant's claimed invention. Kearney does not teach that fluid is discharged "from the channel exits substantially uniformly throughout the vessel volume", as is required by Applicant's claims. As discussed at page 4, lines 10-13, of Applicant's specification, Kearney describes a distributor or a collector, for use as a uniform fluid transfer device at a discrete, cross-sectional zone: the interface between various liquid phases in a column or cell accommodating a plug flow operation, i.e., at the inlet or outlet of a vessel, not within it. (See, e.g., Kearney, column 2, lines 35-51 and lines 59-63; claim 1, at column 7, lines 10-14, according to which, the fluid is injected in discrete zones so as to obtain plug flow.) Kearney's distributor/collector is designed to preserve a fluid's laminar flow and thus to avoid any turbulent-to-laminar flow transition that would mix the fluid (see, e.g., column 1, lines 35-42). Kearney contains no teaching suggesting its adaptation for operating a multi-phase process such as Applicant's system (e.g., claim 1 and dependent claims thereof). The ordinarily skilled artisan would not expect to be able to, or be motivated to, use Kearney's single-phase, laminar-flow system to operate a

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multi-phase process, because he or she would realize that a multi-phase process usually requires turbulent or non-laminar flow rather than laminar flow. (See, e.g., enclosed Coppens Declaration, paragraph 4.)

Kearney also contains no suggestion of the possibility of scaling up the system from a laboratory or test model to an industrial-scale system, in a predictable and easy way (e.g., Applicant's claim 6 and claims dependent thereon). Kearney also fails to teach or to suggest the exact geometry and dimensional relationship of Applicant's network (e.g., claims 3, 4, 7, 8, 10). Kearney thus fails to provide the distinct advantages of Applicant's invention, as previously discussed in relation to Cox et al. Kearney also fails to teach the specific processes in which Applicant's invention may be used (claim 5).

For the foregoing reasons, Applicant's claimed methods, vessel, and hierarchical network are not disclosed in Kearney but are novel and non-obvious. Therefore, withdrawal of the rejections based on Kearney, U.S. Patent 5,354,460, is requested.

Kearney, Fractals in Engineering

Claims 1-13 also stand rejected as allegedly anticipated by, or obvious over, Kearney, Fractals in Engineering (for the reasons set forth in the Office Action, Page 4, paragraph 8 of Paper No. 5). Applicant traverses in view of the amended claims and the following reasons.

The Fractals publication describes a mixing device which is designed to *avoid turbulence* (see e.g. page 2, lines 1-7). It follows that this device requires the possibility of mixing the fluids, i.e., the fluids must be miscible and must therefore form a *single phase*. In contrast, amended claims 1 and 6 specify that the method is for operating a multi-phase

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process, which process often requires turbulence or non-laminar flow, as one of ordinary skill in the field of the invention would have known at the claimed priority date. (See, e.g., Applicant's specification at page 2, lines 8-10 and 29-34, page 3, lines 4-5; and enclosed Coppens Declaration, paragraph 4, and attached excerpt from Encyclopedia of Chemical Technology.) For example, the successful operation of fluidized bed reactors (e.g., in Applicant's claim 5) requires turbulence to obtain favorable mass and heat transfer characteristics. The ordinarily skilled artisan would have expected that Kearney's device as described in the Fractals article, to be useful only for a single-phase, laminar process. He or she would not have been motivated to use Kearney's device or teachings to develop Applicant's methods and structures for operating multi-phase processes (e.g., claims 1, 6, and 7 and their dependent claims). In addition, the device of Kearney et al. is "space-filling" (see e.g. the caption of Fig.1), and thus does not teach or suggest the geometry or dimensional relationship of Applicant's network. As explained in Applicant's specification (e.g., the paragraph bridging pages 12 and 13), a space-filling structure corresponds to a situation wherein all points within the embedding space in which the network lies, are reached. Thus, Kearney et al.'s structure corresponds to a network in which D equals 3. In contrast, in Applicant's structures (see, e.g., amended claims 7 and 10), $2 < D < 3$, such that the resulting network makes use of the volume it extends in. At the same time, Applicant's network avoids interference with the fluid inside the vessel that may be in motion, and leaves enough space for the multi-phase process that takes place inside the vessel. (See, e.g., Applicant's specification, page 9, lines

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25-30.) Thus, Applicant's claimed structures are not known or obvious from Kearney et al., and they provide unexpected advantages lacking in, or insufficiently provided by, the prior art, as discussed previously with respect to the other applied references. Furthermore, Kearney's Fractals article fails to teach the specific processes in which Applicant's invention may be used (claim 5). Additionally, Kearney's Fractals article does not teach or suggest Applicant's predictable method of scale-up (claim 6), for the reasons set forth in the earlier discussion of Cox et al.

Therefore, Applicant's claimed inventions are both novel and non-obvious. Withdrawal of the rejections based on Kearney's Fractals article is requested.


Other Cited References

The Office Action, at paragraph 9, also cites, but does not apply, WO-A-98/14 268 and corresponding US-A-5 938 333 (also to Kearney et al.). Those documents disclose a *method for avoiding turbulence*. As discussed previously, the presence of turbulence is a requirement for practicing most multi-phase processes. Moreover, Kearney's fractal distribution structures are space-filling (see e.g. page 3, lines 24-25 of WO-A-98/14 268), which makes them different from the structures of the present invention, particularly in terms of the channels' dimensional relationship. As a result, these structures of Kearney et al. lack the advantages obtained with Applicant's present invention. Therefore, these documents also do not teach or suggest Applicant's claimed invention.

In view of the preceding amendments and remarks, Applicant's claimed invention is deemed to be novel and non-obvious over the prior art of record.

The Examiner is encouraged to telephone the undersigned attorney to discuss any matter which would expedite allowance of the present application.

Respectfully submitted,

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Dated: 1-29-1

CLG/mc/242422.2

Enclosure: Declaration of Marc-Olivier Coppens and
Encyclopedia of Chemical Technology extract
attached thereto

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